MANSOURA UNIVERSITY
FACULTY OF ENGINEERING
DEPARTMENT OF ELECTRONICS & ELECTRICAL COMMUNICATIONS

ELECTROMAGNETIC FIELDS
SECOND YEAR EXAM
JAN 2009

Attempt the following questions — Time 3 hours

1- The spherical region $r < 2.0$ is filled with electric charge of uniform density $q_v = 2$ nC/m^3. Determine:
a- The total charge inside the region.
b-The electric field at the points A (0,1,0) and B (0,4,0).
c- The voltage difference between points A and B.

2- A parallel plate capacitor is made of two perfectly conducting square plates 50 mm on a side seperated by 10 mm. A slab of sulfur of relative dielectric constant $\varepsilon_r = 4$ and thickness 6 mm is placed on the lower plate, leaving an air gap of 4 mm thick between it and the upper plate. If the lower plate is at 0 voltage and the upper one at voltage 20 V, find the electric field **E**, the electric flux density **D**, and the polarization **P** in each region. Determine also the charge density on each plate and the total energy stored between the plates.

3- Write Laplace's equation in cylindrical coordinates (r, φ,z).
A coaxial line has an inner conductor of radius a = 2.0 mm and an outer conductor of radius b = 4.0 mm. The region $2.0 < r < 4.0$ between the conductors is filled with a dielectric of ε_r = 2.25. By solving Laplace's equation, determine the potential and electric field distributions in the space between conductors. Show that the capacitance per unit length of the line is
$C = 2\pi\varepsilon / \ln(b/a)$, where $\varepsilon = \varepsilon_o \varepsilon_r$. If a two-layer dielectric is used such that:
$\varepsilon_r = 2.25$ $2.0 < r < 3.0$, $\varepsilon_r = 4.0$ $3.0 < r < 4.0$, find the capacitance per unit length.

4- An infinitely long thin wire on the z axis carries a current of 10 mA in the z-direction. Find the magnetic field **H** at the point (0,1,0). If a short wire of length dL is placed parallel to the z axis through the point (0,1,0) and carries a current 5 mA in the z-direction, what will be the force on this short wire? Is the force between the two wires attractive or repulsive?
The half space $z > 0$ is air while the region $z < 0$ is filled with a ferrite material for which $\mu_r = 64$. If $\mathbf{H} = 4\,\mathbf{a}_x + 5\,\mathbf{a}_y + 3\,\mathbf{a}_z$ mV/m in air, find **H** and **B** in the ferrite material.

5- An electron starts motion at the origin with a speed $v_o = 2\times10^6\,\mathbf{a}_y$ m/sec. A uniform magnetic field parallel to the z axis and with flux density 5.0 mWb/m^2 exists in the region. Describe the electron trajectory through the field. What would be the path if an electric field $E = 20\,\mathbf{a}_z$ kV/m were present?

6- Write Maxwell's equations in differential (point) form. Using these equations, show that in free space **E** satisfies the wave equation $\nabla^2 \mathbf{E} = \mu\epsilon\,\partial^2\mathbf{E}/\partial t^2$.
A certain microwave transmitter produces a uniform plane wave in free space having a wavelength 0.12 m. The power density is 10×10^{-6} W/m^2. Determine the frequency, the phase shift constant, and the rms values of the electric and magnetic fields. When this wave propagates through a dielectric material, its wavelength is reduced to 0.06 m. Determine the phase velocity in this material and its dielectric constant ε_r.